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CHEMISTRY AND HYDROLOGY OF CURRENT AND POST-DREDGING MERCURY DISTRIBUTIONS IN BERRY'S CREEK

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INTRODUCTION

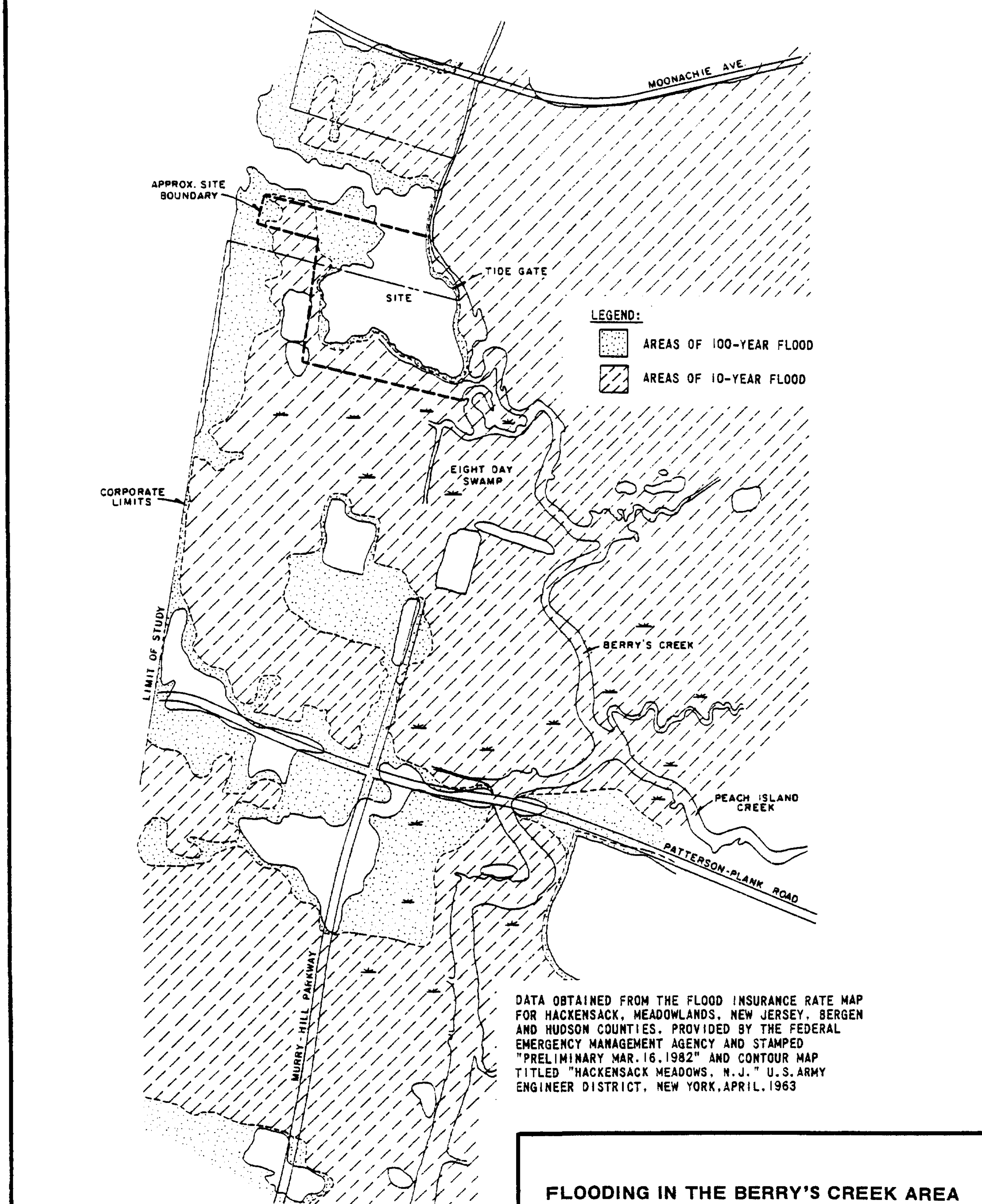
Past monitoring and analyses in the vicinity of the dismantled mercury processing plant at Berry's Creek (Figure 1) have determined that significant levels of mercury occur in the Berry's Creek sediments. There is currently no evidence of toxic levels of mercury or methyl mercury in the surface water of the creek or marshes. A previous study[1] indicated a potential for increased concentrations of dissolved mercury in Berry's Creek during dredging operations. The study considered the geochemistry of the sediments and creek, based on existing data, but did not consider dilution. This report summarizes and interprets recent chemical analyses of water and sediment samples from Berry's Creek, the estimated effects of dilution, and data related to flooding in the Berry's Creek Basin.

SAMPLING AND CHEMICAL ANALYSES

A site visit was made March 17-18, 1982 to collect sediment and water samples for additional chemical analyses. The goals of this program were to (1) more precisely relate the mercury distribution to depth and the sediment type (i.e., sand or organic matter), (2) confirm the assumptions used in the GEOCHEM model, (3) obtain data on the distribution of organic forms of mercury and (4) obtain data on any other metals which may be present above background levels.

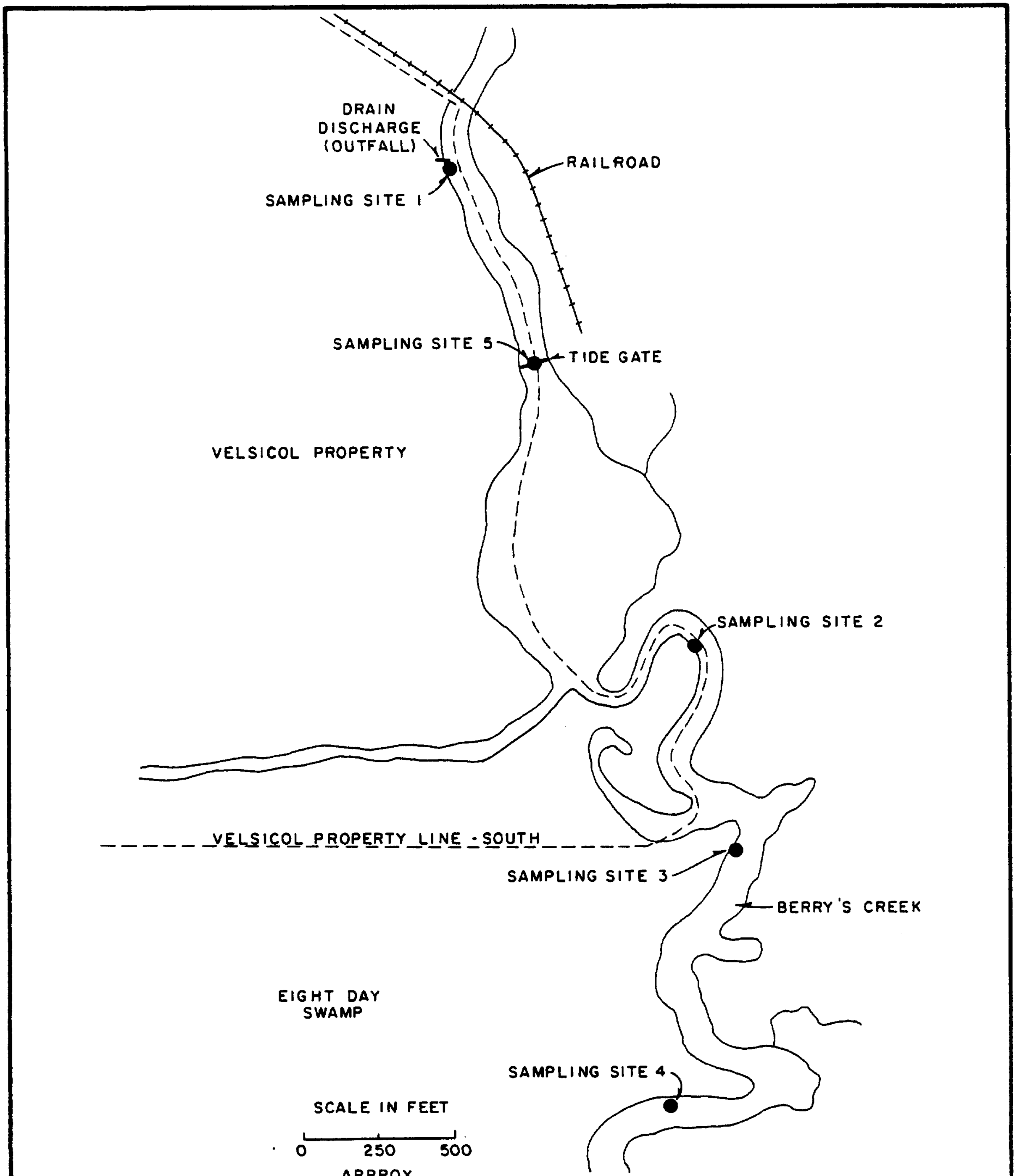
The locations of the sampling points are illustrated in Figure 2 and are described in Table 1. The sediments were collected at low tide, from points in the Creek within 6 feet of the banks. Samples of each sediment horizon were removed from the coring device, placed in precleaned jars, and packed on ice prior to shipping. In general, the samples consisted of thick layers of black organic material underlain by sand. Complete cores were obtained at Locations 2, 3 and 4 where sand layers existed within the four-foot sampling depth. No sand layer was encountered at Location 1. The lack of a sand layer in the core increased the difficulty of sampling the highly compressible and soft organic matter. Thus, at Location 1, there is more uncertainty as to the depth of sediment sampled (due to loss of material while removing the coring device) and the potential for cross-contamination with depth.

Water samples were collected at high and low tides from the downstream side of the tide gate adjacent to the site (See Figures 1 and 2). Samples were packed in ice and shipped with the sediment samples to arrive at the laboratory the next day.



FLOODING IN THE BERRY'S CREEK AREA

FIGURE 1



SAMPLING LOCATIONS (3/17-3/18/82)

FIGURE 2

Results of the mercury analyses are presented in Table 1. In general, the results confirm previous studies that very little of the mercury is present in soluble forms under current conditions. Mercury concentrations in the sediment are much higher in the organic sediments (O) than the sand or clay (S/C). Organic forms of mercury in the sediment were found in concentrations which generally increased with depth. Several surface samples showed no detectable levels of organic mercury at the surface, even in the most heavily contaminated areas. The presence of high levels of organic mercury at depth (below the level of greatest bacterial action) and the low solubility of that mercury suggests that the main species present is phenyl mercuric acetate rather than methyl mercury. The organic mercury analysis includes phenyl mercuric acetate, an industrial form of mercury, as well as methyl forms of mercury. Additional analytical work would be required to resolve the distribution of the organic species.

The solubility of the mercury in the sediment was found to be very low based on an acidic extraction (EPA toxic extraction procedure) of the organic sediment layer. All concentrations were at or only slightly above surface water standards (0.002 ppm Hg), and would probably meet these standards after dilution with the Creek water. The leachate concentrations of mercury were also well within EPA criteria for non-hazardous wastes (less than 100 times drinking water standards, or 0.2 ppm Hg). The concentration of mercury in the surface water was within both drinking water and surface water standards at both high tide and low tide.

Additional laboratory analyses were performed to detect the presence of other metals in the sediment. Based on current data and previous analyses by the USEPA[2], barium, chromium, copper, zinc, tin and silver are present in levels above the average of mineral soils[3]. Results are summarized in Table 2. These metals may be the result of past disposal practices or current permitted discharges. Current surface water discharges in the area are permitted to include low levels of chromium, phenols, zinc, oil and grease, and copper (based on information recorded in NPDES permits). Cooling water discharges may contain chromium or zinc corrosion inhibitors, and plant drainage collection systems may contain spilled raw materials or other surface deposits. One industry in the area of Eight Day Swamp uses phenyl mercuric acetate in their industrial process as a raw material.

Analysis of parameters used in the GEOCHEM model indicates that the actual chemical conditions found in the March, 1982 sampling program are within the range of values

TABLE 1: SAMPLING LOCATIONS, SEDIMENT DESCRIPTIONS, AND MERCURY CONTENTS (3/17/82 SAMPLING TRIP)

Sample Number	Location	Sediment Type	Description	Total Inorganic Mercury (ppm)	Total Organic Mercury* (ppm)	Inorganic Mercury In Solution After Acid Extraction (ppm)
1.1	3-6 ft. South of discharge point, 1-3 ft. offshore (at high tide), depositional environment	O	0 to 1" depth; organic material, much decomposed; somewhat oxidized, brown to black (7.5 YR 2/0)	65	ND	—
1.2	Same as 1.1	O	3" to 18" depth, similar to 1.1 but with no evidence of oxidation, black (7.5 YR 2/0)	700	ND	0.005
1.3	Same as 1.1	O	18 to 30" depth, similar to 1.2	1700	300	—
1.4	6 ft. south of discharge point, 2 ft. offshore (at high tide) near slight rise in bank, depositional environment	S/C	3 to 18" depth, silty clay with high organic matter content, very dark gray (2.5 Y 3/1)	9.2	3.3	—
1.5	Same as 1.4	S/C	18 to 36" depth, similar to 1.4	6.3	5.4	—
2.1	Near station 28 of AWARE study; inside of creek bend, in area where erosion approximately equals deposition; sample taken approx. 3 ft. from bank, at low tide	O	0 to 1" depth, organic material, much decomposed, somewhat oxidized at surface, brown to black (7.5 YR 2/0) with some areas of iron oxide staining	38	ND	—
2.2	Same as 2.1	O	1 to 30", similar to 2.1 but with no evidence of oxidation	17	ND	0.006
2.3	Same as 2.1	S/C	30 to 42" depth, sand, very dark grayish brown (2.5 Y 3/2)	5.6	5.4	—
3.1	Near station 34 of AWARE study; on inside of bend in depositional environment; sample from approx. 6 ft. from bank, at low tide	O	0 to 1" depth, similar to 2.1	30	6.6	—
3.2	Same as 3.1	O	1" to 34" depth, organic material, much decomposed; black (7.5 YR 3/0); one sand layer (approx. 1" thick) observed but not included in composite sample	110	<10	0.005
3.3	Same as 3.1	S/C	34" to 42" depth, sand, very dark grayish brown	2.6	0.3	—
4.1	Near station 44 of AWARE study; deposition exceeding erosion, sample from approximately 6 ft. from bank	O	0' to 1" depth, organic material, much decomposed, surface oxidation, brown to black (7.5 YR 2/0)	45	ND	—
4.2	Same as 4.1	O	1 to 26" depth, organic material, much decomposed, black (7.5 YR 3/0)	110	<10	0.005
4.3	Same as 4.1	S/C	26 to 48" depth, very dark gray (2.5 Y 3/1) sand with dark grayish brown (2.5 Y 4/2) clay stringers at lower depths, some mottling in clay to lighter colors	2.3	2.3	—
5.1	Center of tidegate, downstream side	SW	Water sample taken at high tide	.001	—	—
5.2	Same as 5.1	SW	Water sample, taken at low tide	.001	—	—

* May include compounds of industrial origin (e.g. phenyl mercuric acetate) and/or those formed under natural conditions (e.g. methyl mercury)
— Not determined
ND Not detected
O High organic matter content
S/C Predominantly mineral sand or clay
SW Surface water

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TABLE 2: CHEMISTRY OF THE BERRY'S CREEK SEDIMENTS

Parameter	Concentration or Value	Source of Data	Normal Range in Soils
Metals:*			
Lead (total)	38 to 250 mg/kg	Mar, 1982 study	2 to 200 mg/kg[3]
Silver (total)	0.5 to 6.8 mg/kg	Mar, 1982 study	0.1 to 5 mg/kg[3]
Zinc (total)	0.11 to 4700 mg/kg	Mar, 1982 study	10 to 300 mg/kg[3]
Barium (total)	5000 to 10,000 mg/kg	1977 EPA study	100 to 3000 mg/kg[3]
Chromium (total)	400 to 1000 mg/kg	1977 EPA study	1 to 1000 mg/kg[3]
Copper (total)	30 to 400 mg/kg	1977 EPA study	2 to 100 mg/kg[3]
Tin (total)	100-600 mg/kg	1977 EPA study	2 to 200 mg/kg[3]
General Chemical Parameters:			
pH	6.8-8.0	Mar, 1982 study	5.5 to 8.0[4] (waterlogged soils)
Eh	-300 mV**	Mar, 1982 study	-350 to +200 mV[4] (waterlogged soils)
Sulfur (measured as sulfate in water sample)	76 ppm	Mar, 1982 study	—
Inorganic N (water sample)	1.2 ppm	Mar, 1982 study	—
Iron (easily extractable)	27 ppm	Mar, 1982 study	—
Manganese (easily extractable)	8.9 ppm	Mar, 1982 study	5-100 ppm[5]

*Other metals (Ni, Se, Fe, Mn, Co, As, Cd) within normal range.

**Highly variable due to difficulties in measuring Eh in soil systems.[6,7]

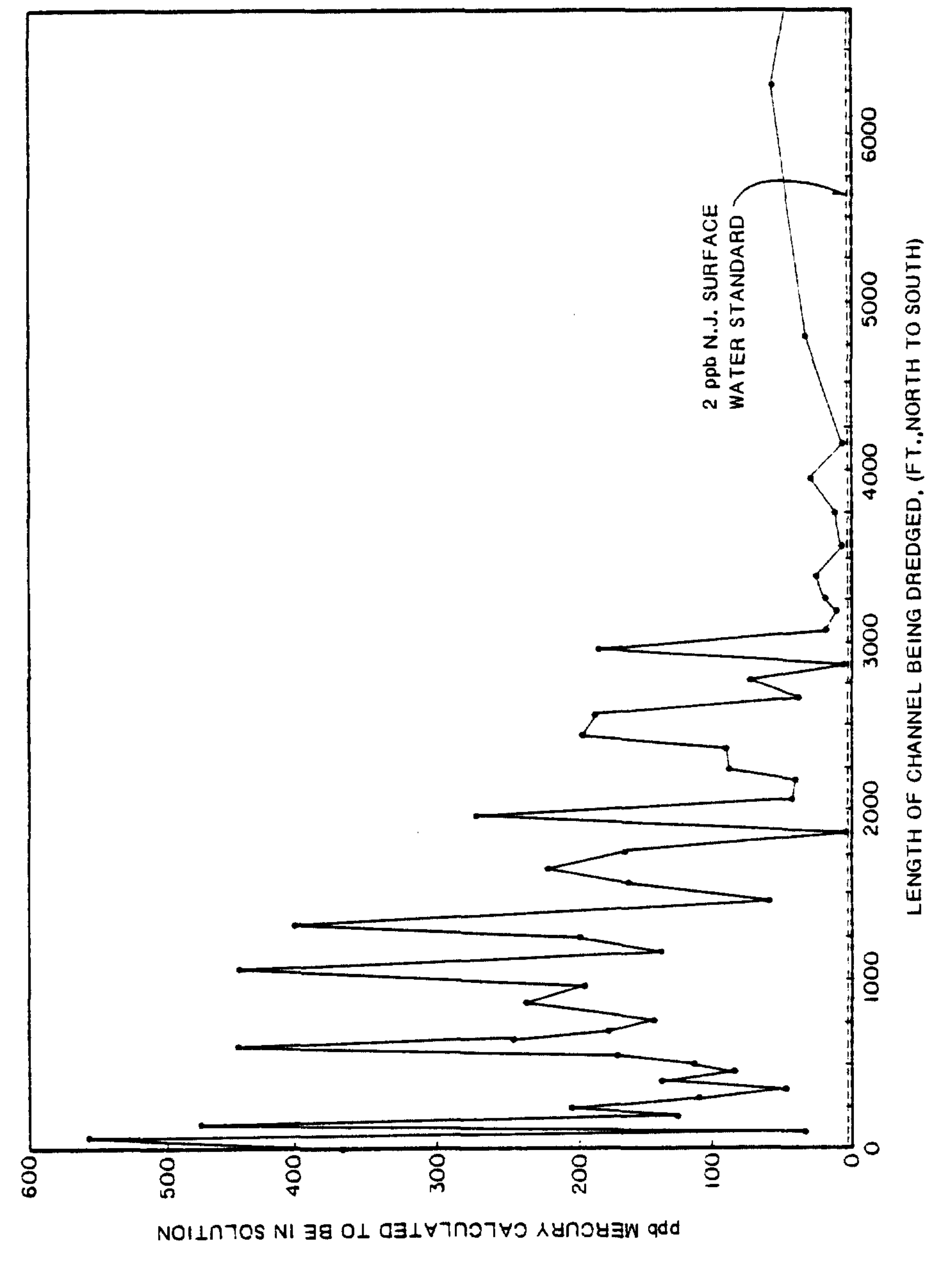
assumed in the original report, and the conclusions reached have not changed. The model results predict that 100% of the mercury under present conditions would remain in the sediment. After dredging, the model indicates that most of the mercury (92.5 to 99.6%) would be solubilized. The chemical parameters measured in the sampling program and used in the program are given in Table 2. The same model indicates that the solubility of chromium, copper, lead and silver may increase due to oxidation of the sediment during dredging. Based on the limited number of sampling points, however, the calculated concentrations of the metals other than mercury would be within surface water standards after dilution with the Creek water.

DILUTION EFFECTS

Berry's Creek is subject to both tidal influences and a net outward flow toward the Hackensack River. Information obtained from the Hackensack Meadowlands Development Commission (HMDC)[8] indicates that under normal conditions at the Route 3 Bridge, the tidal flow is approximately 160 million gallons per tidal cycle and the net outflow is 15.8 million gallons per day. These flow data were combined with a number of assumptions related to the rate of sediment uptake during dredging and the amount of sediment which would be lost during dredging. It is believed that these assumptions, discussed in more detail in Appendix A, are generally conservative in nature. Using these assumptions, the final concentration of mercury in the Creek and the cummulative mercury releases were calculated. The results, assuming a 95 percent dredging efficiency, are presented in Figures 3 and 4. In general, the calculated values exceeded New Jersey Surface Water Standards by two orders of magnitude or more in the most contaminated areas even when dilution and efficient dredging are assumed.

DISPOSAL OF THE DREDGE SPOILS

Disposal of the dredged material would require dewatering and discharge of the water mixed with the sediments during dredging. If the water:sediment mix is completely oxidized during mixing, dredging and disposal, then 92 to 99% of the mercury is calculated to be solubilized in the water. The cumulative mass of mercury released to the water per linear foot of channel dredged is presented in Figure 5. Discharge of this very large volume of contaminated water back to the Creek would have a substantial effect on water quality in Berry's Creek.



MERCURY CONCENTRATIONS CALCULATED TO BE IN SOLUTION, AT THE ROUTE 3 BRIDGE AFTER DREDGING AND DILUTION (ASSUMES A 95% DREDGING EFFICIENCY)

FIGURE 3

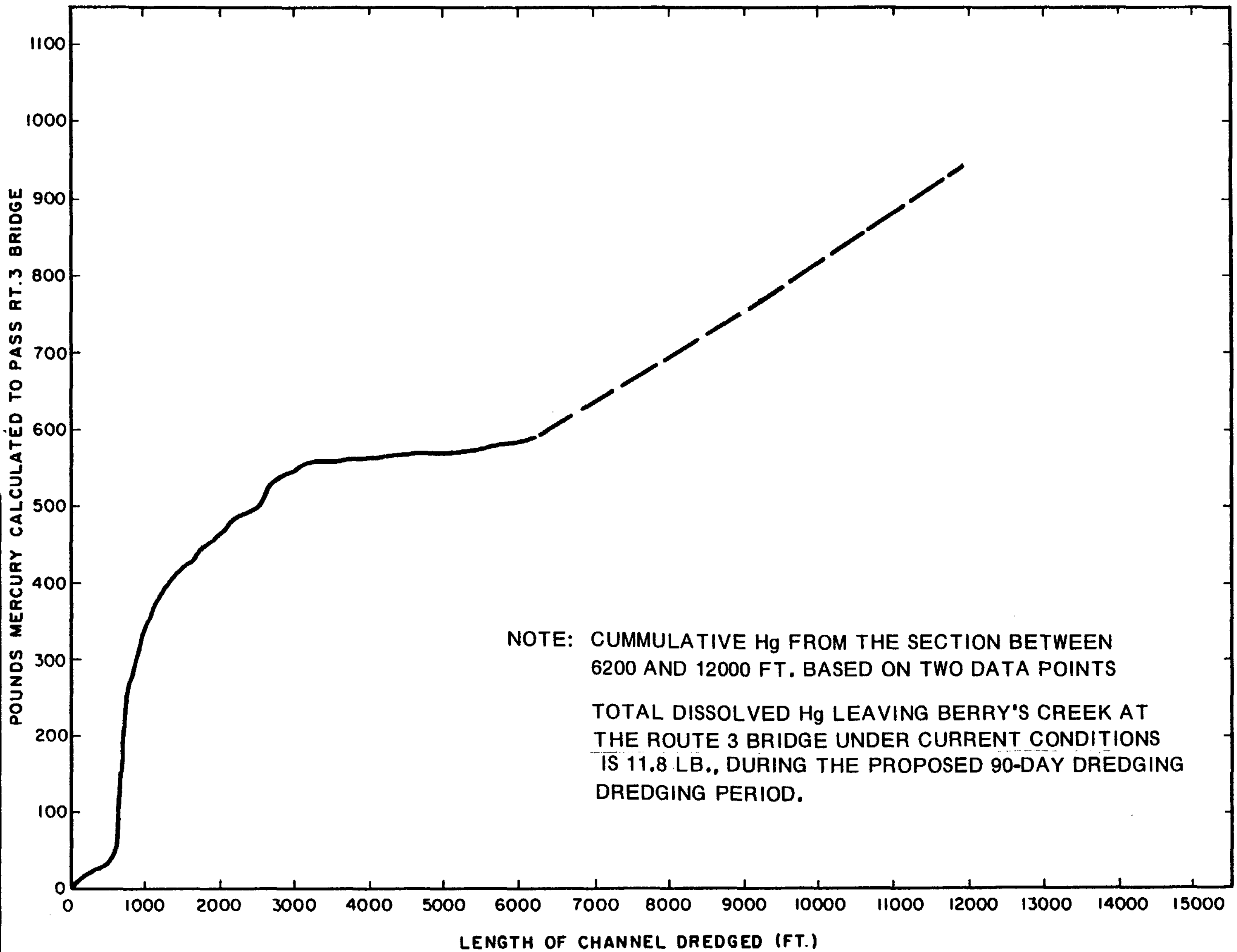
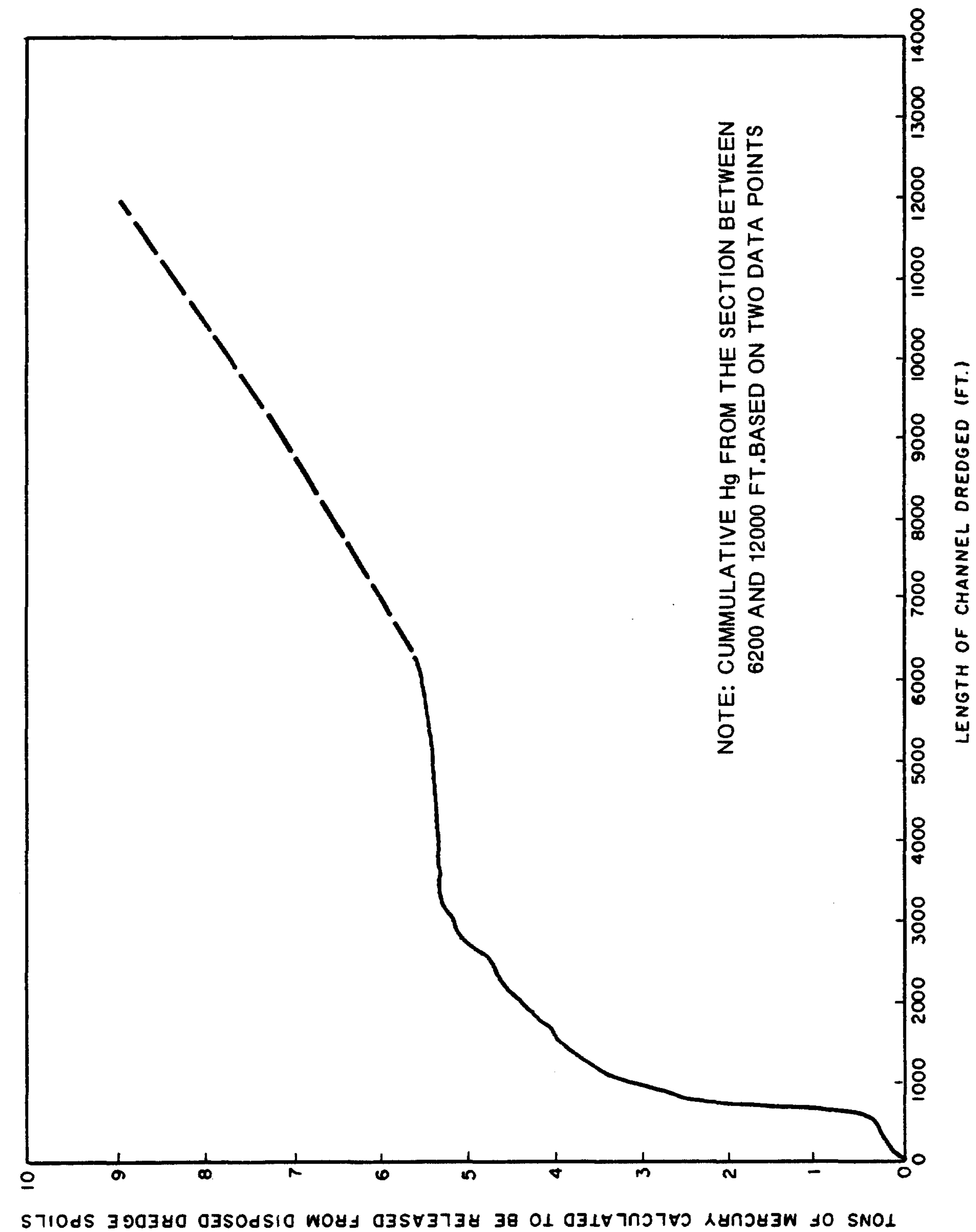


FIGURE 4

CUMMULATIVE MERCURY RELEASES CALCULATED AT THE ROUTE 3 BRIDGE, ASSUMING 95% DREDGING EFFICIENCY



CUMMULATIVE MERCURY RELEASES TO THE WATER IN THE DISPOSED DREDGE SPOILS (CALCULATED, ASSUMING COMPLETE OXIDATION OF THE SEDIMENT: WATER MIXTURE)

FIGURE 5

FLOODING IN BERRY'S CREEK

Berry's Creek Watershed, as part of the larger Hackensack River Watershed, has been studied in detail for several years for both normal and flood flow conditions. It has been reported that the Hackensack Meadowlands Development Commission is continuing to collect data on normal flows in Berry's Creek as part of their continuing study of downstream movement of mercury contaminated water and sediments. The most recent detailed study of flooding conditions in the Hackensack Meadowlands, and Berry's Creek, is contained in the "Flood Insurance Study, Hackensack Meadowlands; New Jersey, Bergen and Hudson Counties."[9] Although presently (March 1982) available only as a preliminary report, it is believed technical data and results contained therein are not subject to significant changes.

FLOOD INSURANCE STUDY

Information contained in the Flood Insurance Study concerning Berry's Creek is summarized in the following paragraphs. The scope of the study included the Hackensack Meadowlands, located in Bergen and Hudson Counties, New Jersey, approximately 5 miles west of Manhattan, New York. Berry's Creek was one of 12 Hackensack River tributaries selected for study by detailed methods. Peach Island Creek, which empties into Berry's Creek upstream of Patterson Plank Road, was also studied by detailed methods.

Berry's Creek and Peach Island Creek are located in tidal swamps. Tidal variations are about five feet in Berry's Creek in the vicinity of the site. The confluence of Berry's Creek and Berry's Creek Canal with the Hackensack River are approximately 7.3 and 8.2 miles, respectively, upstream from Upper Newark Bay. Upland portions of Berry's Creek Watershed extend to elevation 200, obviously beyond the range of tidal influence. The Flood Insurance Study results also indicate that flooding in the upper reaches of Berry's Creek, in the vicinity of Teterboro Airport, results from fluvial (rainfall runoff) rather than tidal effects.

Flooding at any point of the Hackensack, or Berry's Creek, Watershed may result from one or more of the following causes: (1) rainfall runoff, (2) astronomic (predicted) tide, (3) surge (the portion of the storm tide produced by wind shear on the ocean surface of the continental shelf off New York Bay), and (4) wave runup. All of these factors must be analyzed and combined in order to predict the expected 10-, 50-, 100- and 500-year flood elevations.

RAINFALL RUNOFF: The climate of the area is typical of the Middle Atlantic coastal areas where marked changes in weather occur, especially in the spring and fall. The storm types most likely to produce record flooding are the winter storms known as "northeasters", or summer storms known as "hurricanes" or "tropical storms". Either storm type may produce flooding as a result of surges and/or rainfall runoff.

ASTRONOMIC TIDES: The predicted tides vary throughout the year, spring to neap, and gradually over time. Records indicate that the median high tide for January is 0.66 feet below the predicted September median high tide in the New York area. In addition, the sea level in the New York area is increasing by 1.2 feet/100 years. Therefore, the long-term change in tide levels must be considered when analyzing flooding by historical storms. All available tide records were obtained, some dating back to 1893. Some records were discarded as being affected by other factors (gate operations at Overpeck Dam) or being too short for a frequency analysis.

SURGES: Critical storm-tide flood levels are produced in the Meadowlands when surge peaks correspond to astronomic tide peaks. It has been found that a high storm-tide elevation created by a hurricane may be less critical to tidal flooding than a lower "northeaster" storm-tide of longer duration. This statement is qualitatively supported by comparing the length of the tide cycle (12.4 hours) with the length of a hurricane surge (17 hours) and the length of a "northeaster" surge (48 hours).

WAVE RUN UP: Wave runup becomes an important factor when wind travels long distances over open water. The complex topography of the area limits the local wind set-up to about 0.5-foot and is not an important cause of flooding in the Meadowlands.

HYDRAULIC ANALYSES: A finite difference model, LATIS, was developed by Tippets-Abbet-McCarthy-Stratton (TAMS) to predict a level of flooding expected to occur once every 200 and 1000 years. From these computer runs, and previous studies made by TAMS under contract to the U.S. Corps of Engineers, the maximum expected flood level for 10-, 50-, 100-, and 500-year was determined. (These return intervals are long-term average recurrence intervals and it is possible that two, or even more, events could occur in any one year.) The watershed is modeled by considering it to be a system of reservoirs (nodes) and channels (links). The most recent topographic information was used to define (reservoir) characteristics. Rainfall runoff enters the "reservoirs" and tides of a given frequency are entered at the extreme downstream node.

Results of the analysis are presented in the Flood Insurance Study report in the form of maps delineating areas of potential flooding by the 100- and 500- year storms and as a table of flood levels for the 10-, 50-, 100-and 500-year storms for each each node. A portion of that table is presented in Table 3 and zones of flooding within Berry's Creek area are shown on the enclosed Figure 1. The 100-year flood inundates most of Berry's Creek Watershed located east of Route 17, including most of Teterboro Airport runways. A few isolated, apparently natural, areas and fill areas associated with roadways and buildings escape flooding. Flood Insurance Study limits are political boundaries and, as the site is partly outside of the Hackensack Meadowlands District, the Flood Insurance Rate maps do not indicate whether all of the site is flooded or not. (However, contour maps[10] indicate the site generally escapes flooding during the 100-year event.)

ADDITIONAL INFORMATION: The Flood Insurance Studies are principally concerned with defining the limits of expected flooding and not necessarily with either the velocity or volume of floods. Therefore, TAMS was contacted and provided supplemental information used in this study to estimate potential dilution of mercury and water velocities during a 100-year event, compared to normal flow conditions.

TAMS provided data from the computer runs in the form of tables of water surface elevation, flows, velocity and flow area over one tide cycle at one-hour increments for links connecting nodes. The volume of water moving into Berry's Creek during the maximum surge in a 100-year event was calculated to be about 1520 million gallons. This compares to approximately 160 million gallons of inflow during a normal tide. Table 4 presents the velocities associated with 100-year and normal flows. Although the purpose of the computer model is to estimate maximum water surface elevations rather than maximum velocities, it was reported that the resulting velocities are believed to be representative of channel velocities.

TABLE 3 - SUMMARY OF ELEVATIONS

Node	Node Location	Minimum Bank Elevation	10-year	Elevation (feet) 50-year	100-year	500-year
	Berry's Creek					
11	at the confluence with Hackensack River	—	6.6	8.1	8.7	9.3
65	2700 ft upstream of Interstate 95	—	6.5	8.0	8.6	9.1
66	3900 ft downstream Route 3 Bridge	3.8	6.5	8.0	8.6	9.0
58	at Route 3 Bridge	3.1	6.5	7.9	8.5	9.0
59	3150 ft downstream of Patterson Plank Rd	3.4	6.3	7.7	8.4	8.8
60	850 ft upstream of Patterson Plank Rd at confluence of Peach Island Creek	3.0	6.2	7.6	8.2	8.7
62	adjacent to site	3.0	6.2	7.6	8.2	8.7
63	800 ft upstream of Moonachie Ave(1)	3.0	4.7	5.0	5.3	6.4
	Berry's Creek Canal					
12	at the confluence with Hackensack River		6.6	8.0	8.7	9.2
57	4400 ft downstream of Rt 3 Bridge		6.5	8.0	8.6	9.1
58	at Route 3 Bridge	3.1	6.5	7.9	8.5	9.0

(1) Physical boundary of Moonachie Avenue Bridge reduces storm-tide peak elevation.

TABLE 4: COMPARISON OF WATER VELOCITIES IN BERRY'S CREEK WITH DESIGN VELOCITIES FOR CHANNELS

Case	Conditions	Location	Water Velocity (ft/sec)
Berry's Creek: Measured Velocities	Normal flow, between tides	Rt. 3 Bridge*	0.02
	Normal flow, out-going tide	Rt. 3 Bridge*	1.11
	Maximum Recorded	Rt. 3 Bridge*	1.80
Berry's Creek: Calculated Velocities	100-year flood	Between nodes 58 and 59 (N. of Rt. 3 Bridge)	-3.1**
	100-year flood	Between nodes 59 and 60 (near Paterson Plank Rd.)	-2.5**
	100-year flood	Between nodes 60 and 62 (between site and Paterson Plank Rd)	-2.0**
Design Criteria to prevent scouring[11,12]	Organic clays, clear water	—	2.5 to 3.5
	Organic clays Sediment laden water	—	4.0 to 5.0
	Alluvial silt, clear water	—	2.00 to 3.75
	Alluvial silt, sediment laden water	—	3.50 to 5.00

*from one of four velocity meters at the Rt. 3 Bridge.

**Negative values indicate upstream direction.

The limit of the 100-year flood for the site and the approximate limits of the 10-year flood as shown on Figure 1 was drawn using contour maps[10] also provided by TAMS. The contours have changed significantly in some areas as the result of fill and construction operations, but the fact that the 10-year flood limits are nearly as extensive as the 100-year limits is readily apparent. The significance of this will be discussed in a following section.

NORMAL FLOWS

Stream flow volumes and velocities in Berry's Creek and Berry's Creek Channel have been monitored as part of the on-going study of Hackensack Meadowlands as an ecosystem. Summary information is presented in "Water Quality in a Recovering Ecosystem:A Report on Water Quality Research and Monitoring in the Hackensack Meadowlands, 1971-1975", Hackensack Meadowlands Development Commission, January 1976. Appendices containing detailed information is available for review at the Hackensack Meadowlands Development Commission offices.

A study was conducted in 1974-1975 to characterize "how a representative incoming tide distributes itself, losing velocity, volume and energy as it goes to the various inland creeks, bays, marshes, and river segments of the Hackensack Estuary." Berry's Creek at the Route 3 bridge was one of the seven monitoring points in the estuary. Of the 6900 million gallons/tide cycle entering the estuary upstream of the New Jersey Turnpike, 160 million gallons flows under the Route 3 bridge into Berry's Creek. In addition to tidal flow in the creek, fresh water from rainfall runoff enters the creek. Assuming total rainfall runoff enters the creek, the average fresh water flow in the creek, based on a 42-year rainfall record, is estimated as 15.8 million gallons per day.

The Route 3 bridge continues to be a monitoring station in the Berry's Creek Watershed. Stream velocities for normal flows are measured by four velocity meters at the Route 3 Bridge. Readings from one of the center meters are presented in Table 4.

EVALUATION OF SCOURING POTENTIALS

Downstream migration of sediment-bound mercury depends on the extent to which the creek sediments are disturbed. Under normal flow velocities, the channel bed appears to be stable. However, under flood flows, the increased velocity may disturb the sediments allowing the adsorbed mercury to move downstream. Comparing the 100-year flood velocity information received from TAMS with design criteria for stable, unprotected channels (see Table 4) indicates velocities may be low enough in the areas of highest contamination so as not to erode the creek bed. In general, the velocities measured in Berry's Creek and those calculated for flood conditions are within these maximum design values. The potential for scouring may vary locally, however, due to (1) channel alignment (velocity is increased on outside edge of curve), (2) depth of flow (higher mean velocities are permitted with deeper channels), (3) density of channel materials (higher density materials permit higher mean flows), and (4) frequency of occurrence (a higher velocity may be tolerated infrequently than a lower velocity more frequently).

In general, it is anticipated that the 100-year flood event would not produce appreciably more scouring than an event which has already occurred (i.e. a 10-year flood). This conclusion is based on the fact that once a flood overtops the channel banks, the amount of energy available for scouring is reduced by (1) energy lost in friction in the flood plain and (2) the transfer of longitudinal momentum from the channel to the flood plain (estimated by one researcher[13] to reduce the maximum bed shear stress in the main channel by up to 40%). Calculations comparing this energy loss to the increase in total energy during a large flood would be necessary to quantify the change in scouring potential.

CONCLUSIONS

The additional geochemical and hydrologic analyses completed for this report essentially confirm previous conclusions as to the current stability of the Berry's Creek sediments and the potential detrimental impacts should dredging proceed. Chemical conditions were found to be within the range of those modeled in the original study[1]. That study concluded that mercury solubility would probably increase if the sediment were mixed with the creek water and oxidized. Even with dilution and efficient dredging, mercury concentrations were calculated to greatly exceed surface water standards. In addition, large quantities of mercury may be solubilized in the dredge spoils, creating disposal problems for the large volume of mercury-laden water.

Review of hydrologic data available for this report indicates that (1) measured and modeled flow velocities are comparatively low, (2) these velocities are generally within design criteria for stable, unprotected channels and (3) the volume available for dilution during a 100-year flood is an order to magnitude greater than under normal conditions.

APPENDIX A: ASSUMPTIONS USED IN CALCULATING DILUTION EFFECTS

A number of assumptions were made about dredging operations, the mercury geochemistry, and the hydrology of Berry's Creek in calculating the amount of dissolved mercury after dredging. These assumptions are outlined below.

(1) **DREDGING OPERATIONS:** Since the design of the dredging operation has not been finalized, it was assumed that the dredge would pick up 15 cubic feet of sediment per second, at a 95 percent efficiency rate. Hence, 5 percent of the sediment would escape to the Creek. It was also assumed that the solids content of the dredged material would be 10 percent, resulting in a ten-to-one dilution of the sediment by the dredge itself. Ten to twenty percent solids is the normal range of dredge spoils.

(2) **HYDROLOGY:** The volume of sediment removed by the dredge in a given time period is approximately one-fifteenth the volume of water moving in and out on a tidal cycle during that period, assuming that little mixing occurs and that essentially the same water moves in and out on a daily cycle. The water stored in the channel and the net outflow volume over that same time period is approximately equal to the amount of water needed to dilute the sediment to 10% solids by volume as described above (based on the AWARE[14] data for the solids content of the sediment and estimates of the channel depth). Hence, the net dilution of the sediment is calculated to be 1:150.

(3) **GEOCHEMISTRY:** Results from the GEOCHEM model of the sediment and creek water shows that between 92.5% and 99.6% of the mercury would be present as soluble complexes (e.g. HgX_2^o). For this analysis, it was assumed that 95 percent of the mercury in the sediment would be solubilized. This value corresponds to the calculated percentage of mercury present as $HgCl_2^o$ and $Hg(OH)_2^o$ at the median pH of 7.4. The values used for the sediment mercury concentrations were obtained from the AWARE study.[14] The total amount of mercury in each channel segment was calculated from the mercury concentration for each depth interval, averaged over the entire width of the channel at that segment.

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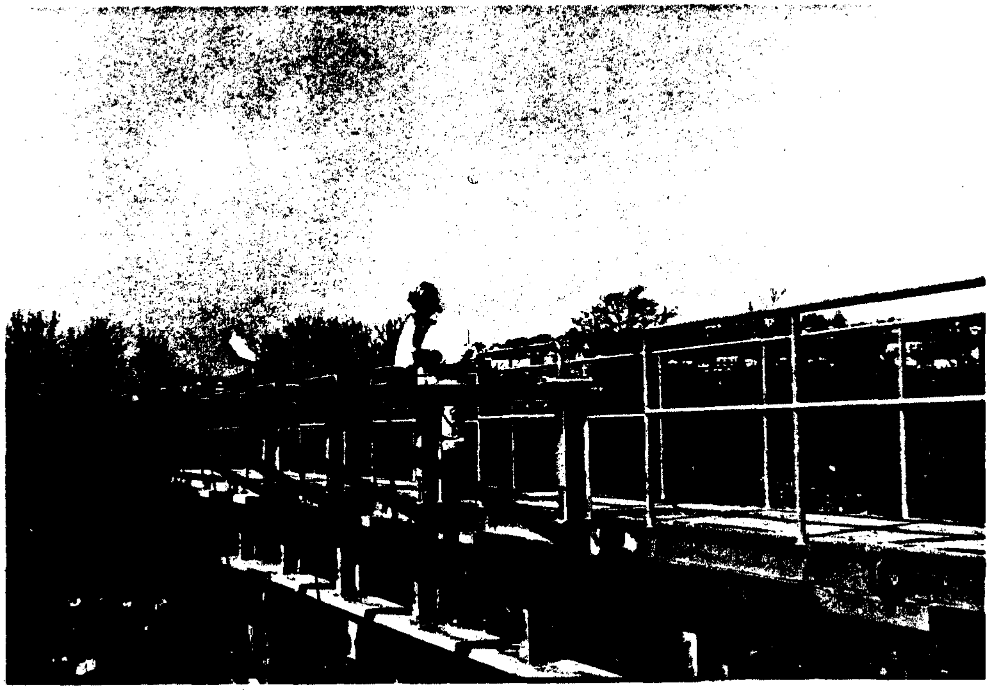
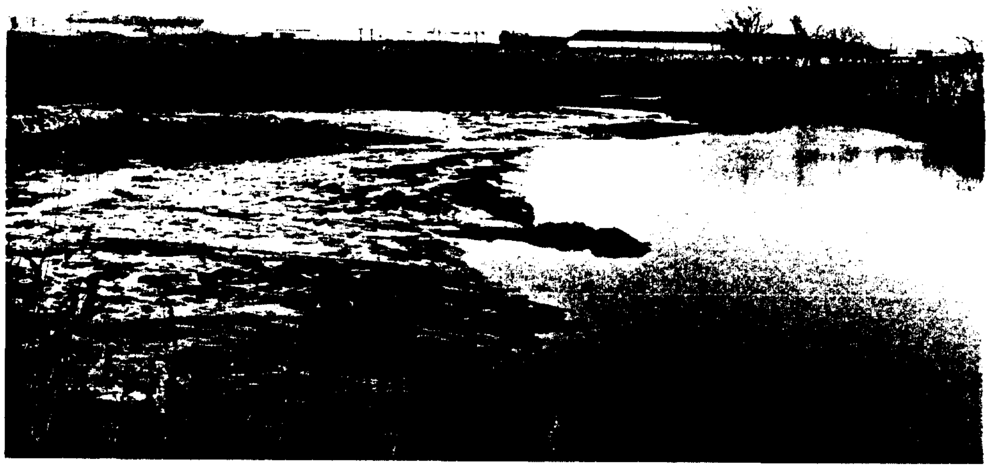
PHOTOGRAPHS

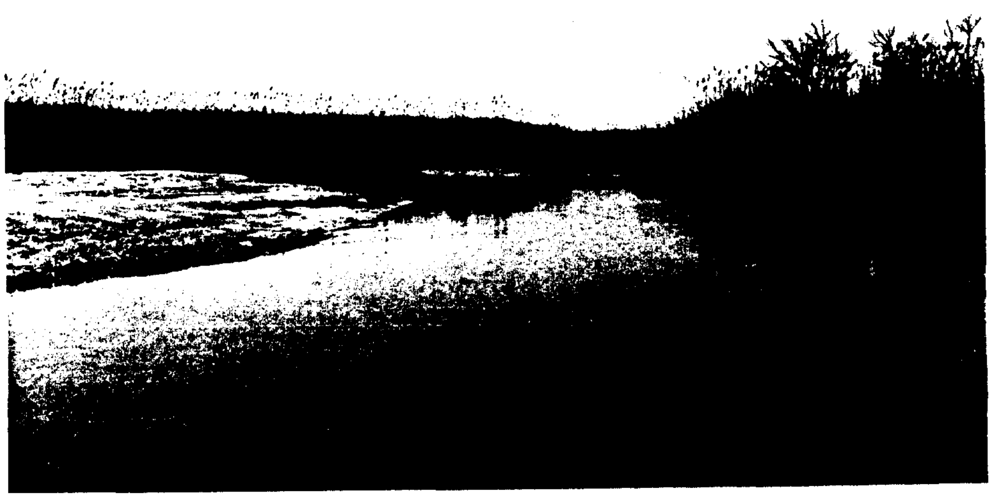


Water sample collection from tide gate

Cleaning bailer before collection of water sample



Pool below tide gate, low tide

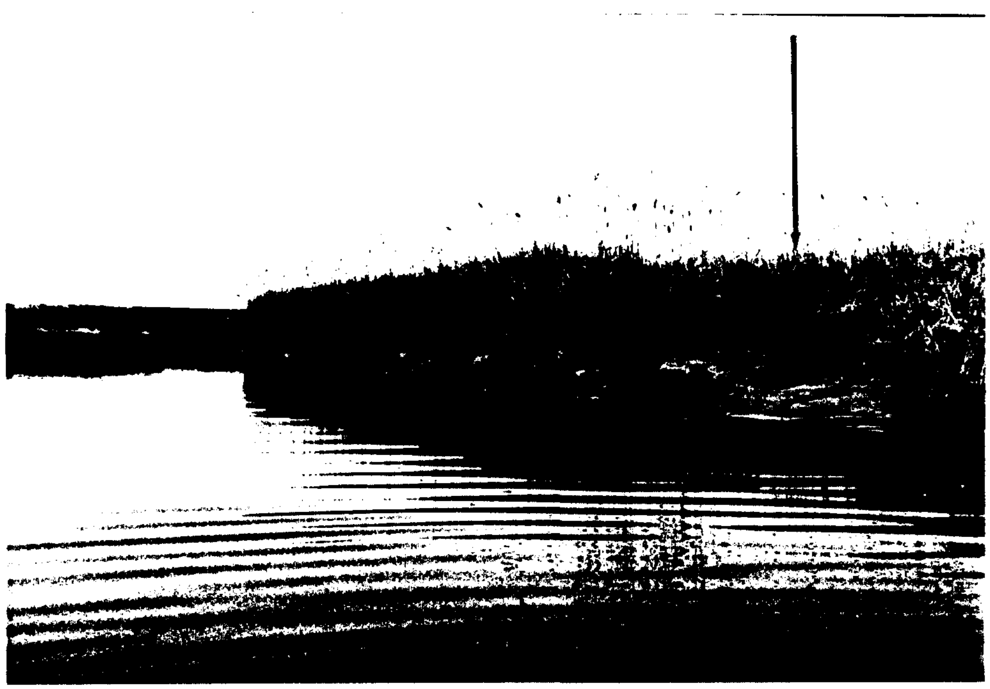


S. section of pool below tide gate low tide

Site after grass fire looking west from below tide gate (low tide)

Confluence, Berry's Creek and ditch on s. side of property

Industrial outfall (cooling water?) along east side of Berry's Creek - Intermittent discharge noted from concrete structure on left

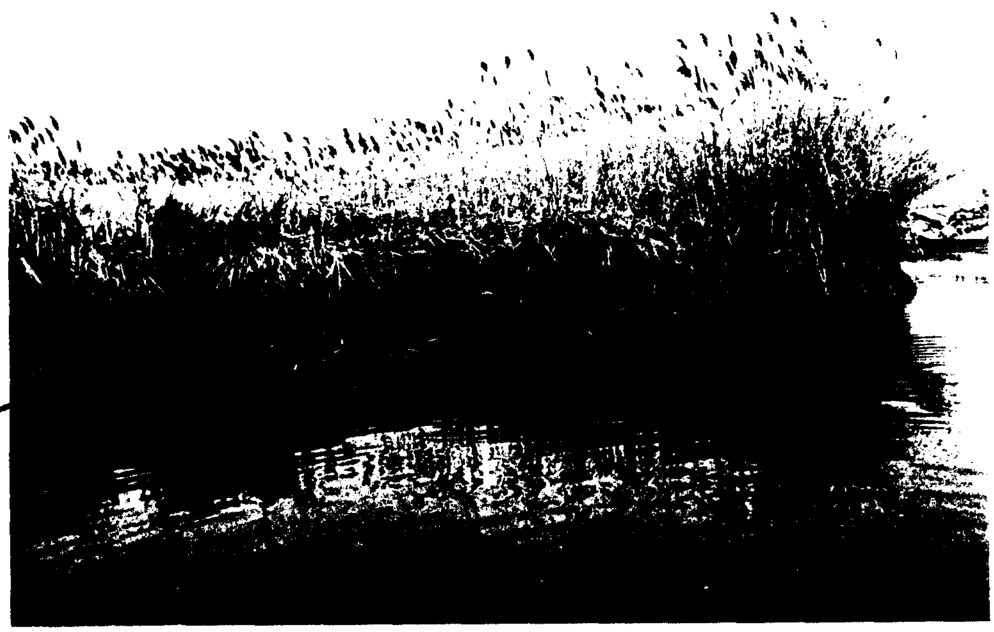


Site 3, low tide

Looking downstream, between site 2 and confluence of unnamed ditch. Note sand bars on both sides of creek

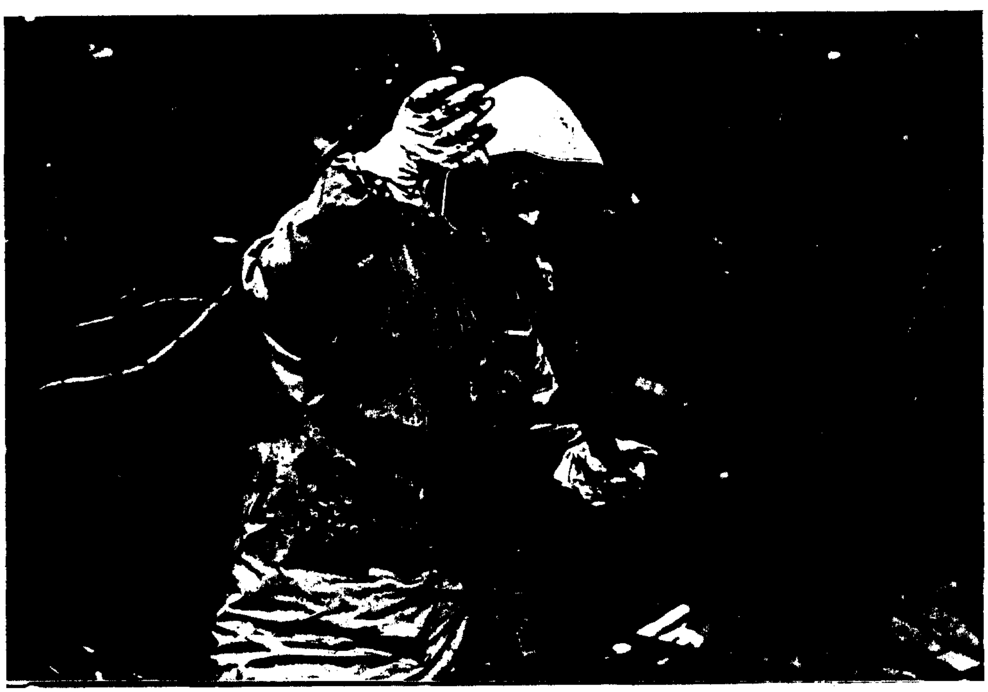
East bank of Berry's Creek across from site 3

Area of recent fill and construction
East side of Berry's Creek, near site 4



Site 4, low tiae

Current marks in organic sediment during low tide
Current in direction of arrow



Site 1: Sampling organic horizon

Removing sand sample from tube - site 4

Site 1: Near outfall sampling organic layer

Site 4, low tide - organic horizon

Site 3, organic horizon
with brown oxidized surface

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West bank of pool below tidal gate